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CIMARRON RIVER DRAINAGE BASIN. A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

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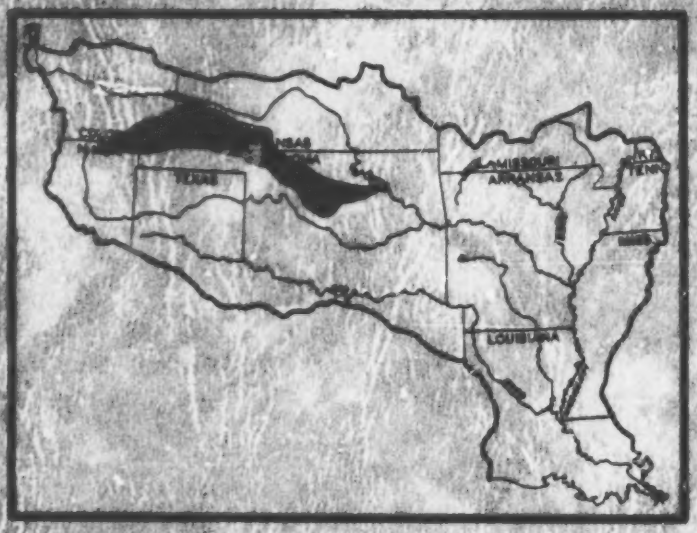
CIMARRON RIVER

DRAINAGE BASIN

A Cooperative State-Federal Report on Water Pollution



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REPORT ON WATER POLLUTION

CIMARRON RIVER BASIN

APRIL 1953

Prepared by

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service

in cooperation with

Colorado State Department of Public Health
Kansas State Board of Health
New Mexico Department of Public Health
Oklahoma State Department of Health

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SUMMARY

General

The basin consists of the entire watershed of the Cimarron River, from its source in northeastern New Mexico to its junction with the Arkansas River above Tulsa, Oklahoma. The basin is over 600 miles in length and drains an area of 19,000 square miles, of which 1,150 are in New Mexico; 2,100 are in Colorado, 6,450 in Kansas, and 9,300 in Oklahoma.

The western two thirds of the basin is semi-arid and stream flows are intermittent. Mean annual precipitation increases gradually from about 16 inches in the western reach to 38 inches near the mouth of the river.

The flow characteristics of the river throughout the basin are extremely erratic. In general, runoff varies from short periods of relatively high flow to long periods of little or no flow.

The Cimarron River is unusual in that its upper reach has little or no effect on the lower section. Very little water in the upper river ever passes a point near Satanta, Kansas. Only the continuous channel indicates that the river should be considered a single stream. The upper reach, in New Mexico, is called the "Dry Cimarron River."

The 1950 population of the basin was about 217,000, about 70 percent of which was in Oklahoma.

Farming and stock raising are principal occupations throughout the basin Industrial development is, for practical purposes, limited to natural gas and oil production and processing in Kansas and Oklahoma.

The major basin water pollution problem is chemical pollution from natural and industrial sources in the lower reach of the basin in Oklahoma.

New Mexico

The New Mexico Basin consists almost entirely of ranch land, without appreciable community or industrial development. There are no community water supplies or sewerage facilities and no sources of industrial pollution. Water uses are confined to rural domestic and stock water supplies and irrigation.

Water supply and conservation is a major problem in the New Mexico Basin Pollution from community or industrial sources is negligible.

Colorado

Major land uses in the Colorado part of the basin are for cattle grazing and dry farming. The water required for extensive irrigation is not available. All municipal water supplies are derived from ground water sources of limited yield. Two municipal sewerage systems, with primary treatment facilities, serve a total population of about 2,400.

Water supply development is a serious problem in the Colorado Basin. Existing damages due to municipal or industrial pollution are minor.

Kansas

Farming is the major land use in the Kansas section of the basin. The Hugoton gas field is the basis for process industries utilizing natural gas in production of carbon black and gasoline.

The High Plains region of the Kansas Basin is one of the few areas in the entire basin in which water supply is adequate and satisfactory in quality for all existing uses and is capable of additional development. Beyond the High Plains area other aquifers have been developed as sources of water supply. In general they yield limited quantities of highly mineralized water. All basin municipal water supplies are derived from ground water sources. The Cimarron River is used directly to some extent for irrigation purposes.

Fourteen municipal sources of pollution in the Kansas part of the basin represent a population of about 21,000. Eleven communities, representing a population of 19,250, provide secondary treatment facilities of adequate capacity. Three community treatment facilities, serving about 1,750 persons, are unsatisfactory with respect to capacity or degree of treatment provided. Industrial waste is not a significant pollution problem.

The Kansas State Board of Health is the primary water pollution control agency. Two other agencies have specialized responsibilities related to pollution control. Existing legislation is considered adequate, in general, for control of existing and potential pollution problems in the basin.

Water supply is not a major problem in the Kansas section of the basin but protection of water resources is very important because very few alternate sources of supply are available. Industrial waste is not a significant problem at present. Existing deficiencies in municipal sewage treatment facilities are relatively minor.

Oklahoma

Farming and stock raising are primary occupations in the Oklahoma Basin. Industrial development is confined largely to oil production and processing in the lower reach of the basin.

Primary water uses are for municipal, industrial and rural domestic, and stock water supplies. A limited acreage of land is irrigated, primarily from ground water sources. Recreational uses of water resources are confined to local areas.

Three municipal surface water supplies have been developed on tributaries of the Cimarron River. The remaining 36 community water supplies in the Oklahoma part of the basin have been developed from several ground water aquifers, including river alluvium. The ground water sources vary widely in both yield and water quality. A few private surface reservoirs on tributary streams have been developed for industrial use and other purposes but the majority of all private domestic and industrial water supplies are derived from ground water sources.

With the exception of the Panhandle section, the Cimarron River in Oklahoma is too heavily polluted from natural and industrial sources for any continuous use in which water quality is significant.

From a water use point of view, the most critical problem in the Oklahoma part of the basin is chemical pollution from natural and industrial sources. The magnitude of pollution of this type is such that it has not only restricted use of the Cimarron River but seriously threatens reasonable uses of Arkansas River water. Data published by the Oklahoma Planning and Resources Board and the U. S. Geological Survey indicate that the Cimarron River is the greatest single contributor of chemical pollution, as measured by chloride concentration, in the Arkansas River drainage system. Its salt contribution is almost equal to that of all upstream sources on the Arkansas River combined and has represented more than one-third of the average chloride content of Arkansas River water as far downstream as Little Rock, Arkansas.

Chemical pollution contributed by natural and industrial sources is similar in character. Sodium chloride is the major pollutant from both sources. Natural sources of pollution extend from near the Kansas line downstream to near Waynoka, Oklahoma, and include mineral deposits, salt plains and saline springs. Very little data are available to define the magnitude of natural pollution but it appears to be very substantial. Heavy discharges of oil field brine further pollute the river in its lower reach. The concentration of mineral salts in the brine (about 17.5 percent as NaCl) is such that very minor flows of brine markedly affect receiving water quality. Seven major oil field areas and four refineries in the basin have inadequate waste disposal facilities.

The Pollution Department of the Division of Water Resources - Oklahoma Planning and Resources Board was established in 1937. Oil fields developed under its regulation and control are not serious sources of pollution. The major contributors of brine pollution are older fields in which oil production is declining and provision of adequate brine disposal facilities has been considered impractical. From a pollution control point of view it is unfortunate that such fields are heavy brine producers and represent a continuous threat to the quality of basin ground and surface water resources.

Nearly all of the 25 municipalities in the Oklahoma part of the basin, representing a population of about 102,400, provide waste treatment of some type but many of the plants are inadequate in capacity or unsatisfactorily operated.

The estimated cost of municipal waste treatment plant improvements required in the basin is about $2,000,000. Nearly half of that amount represents the cost of replacement of the Enid, Oklahoma, plant which is now under construction. Available data does not permit estimation of cost of industrial waste disposal facilities needed.

Pollution control in Oklahoma is a joint responsibility of four agencies. Primary responsibility for protection of water resources and control of pollution from municipal and industrial sources is shared by the Department of Health and the Planning and Resources Board. The Department of Game and Fish and the Corporation Commission also have specific powers related to pollution control. Coordination of pollution control activities is maintained by an informal inter-agency committee on which all four agencies are represented.

At least in terms of chemical pollution, the Cimarron River represents the major pollution control problem in the Arkansas River Basin. Both the magnitude of natural pollution and the economic difficulties involved in

adequate disposal of brine from older fields present serious practical obstacles to control of chemical pollution. Municipal pollution control, in general, is also unsatisfactory. A long-range program, and cooperation of industry, municipalities, and all local, State, and Federal agencies concerned with water pollution and conservation will be necessary to solve basin pollution problems.

CONCLUSIONS

New Mexico and Colorado

(1) Development of new sources of water supply and conservation of existing sources is a major problem in both the New Mexico and Colorado portions of the basin.

(2) Water pollution is a relatively minor problem because of the limited degree and number of sources of pollution.

Kansas

(1) Water supply in the Kansas part of the basin is adequate for existing uses and, in some areas, may be further developed.

(2) All municipal and industrial supplies are derived from ground water sources. Ground water is plentiful in the High Plains region but limited in quantity and of inferior quality in the Permian Redbeds area.

(3) The Cimarron River is directly used to a limited extent for irrigation purposes and serves as a source of recharge of ground water supplies.

(4) Protection of existing ground water supplies is important because very few alternate sources of supply are available.

(5) Industrial waste in the Kansas part of the basin does not, at present, constitute a serious pollution problem but represents a potential hazard to ground water resources because of possible cross-connection of fresh and saline water aquifers through defective oil or gas well casings.

(6) The established programs of the Oil Field and Water Pollution Control Sections of the Division of Sanitation, in cooperation with industry, are expected to control or prevent pollution from existing and future industrial developments.

(7) Relatively minor deficiencies exist in municipal waste treatment works.

(8) Continuous promotion of adequate municipal waste treatment facilities in the basin is necessary because poor drainage and other conditions make high grade treatment essential in order to prevent active nuisance conditions as well as hazards to health.

(9) Existing legislation is considered generally adequate, by the State Board of Health, for control of water pollution. However, limitations in legislation concerning the plugging of abandoned oil and gas wells are considered deficiencies.

Oklahoma

(1) Chemical pollution from natural and industrial sources is the major basin problem related to water use.

(2) The magnitude of chemical pollution is such that it has not only restricted use of Cimarron River water to non-critical uses but seriously affects reasonable downstream water uses in the Arkansas River.

(3) Abatement of chemical pollution is essential to maximum utilization of water impounded in the authorized Keystone Reservoir.

(4) Sources of natural chemical pollution are located in the watershed from near the Kansas State line to the vicinity of Waynoka, Oklahoma, and consist of mineral deposits, salt plains, and saline springs.

(5) Information necessary to define accurately the relative contribution of chemical pollution from natural sources is not available.

(6) Study of possible methods of abatement of pollution from natural sources is fundamental to any overall pollution control program in the Basin.

(7) Since the establishment of the Pollution Department of the Division of Water Resources - Oklahoma Planning and Resources Board in 1937, adequate brine disposal facilities have been required in development on new oil fields.

(8) In many of the older oil field developments which have been declining in oil production brine disposal facilities not considered satisfactory by the Pollution Department have been permitted for economic reasons. Such fields, in general, are heavy brine producers and may continue to be for an indefinite number of years. They represent a serious threat to basin ground and surface water resources.

(9) Seven major oil field areas and four refineries in the Oklahoma part of the Basin have waste disposal facilities considered inadequate by State authorities.

(10) Typical brines of the area contain about 17.5 percent salt (as NaCl), which represents about 70 pounds of salt per 42 gallon barrel. Because of its high salt concentration, comparatively small volumes of brine have extremely adverse effects on receiving water quality particularly when discharge is intermittent.

(11) Supplementary pollution control measures are necessary to abate pollution from oil fields developed prior to 1937.

(12) Only two cities in the Oklahoma part of the basin do not have municipal waste treatment plants. However, of the remaining 23 communities having sewerage facilities, only five are considered by State authorities to have adequate waste treatment works. The operation of 10 plants, of a total of 23, is considered satisfactory.

(13) Pollution control powers in Oklahoma are shared by four agencies. An informal inter-agency committee, on which all agencies are represented, has recently been formed to coordinate pollution control activities.

(14) More than 70 percent of water used for municipal and industrial purposes in the Oklahoma part of the basin is derived from ground water sources. Three municipal surface water supplies have been developed on tributary streams.

RECOMMENDATIONS

New Mexico and Colorado

No recommendations.

Kansas

It is recommended that:

(1) Public information and plant operator training programs be continued and directed toward correction of the relatively few municipal waste disposal plant deficiencies in the basin.

(2) Established activities of the Oil Field and Water Pollution Control Sections of the Division of Sanitation be continued with the objective of preventing, in cooperation with industry, development of industrial waste pollution problems in the basin.

(3) Responsible State water pollution control agencies review existing legislation for the purpose of developing adequate statutes to cope with the following specific problems:

(a) Improper plugging or casing of wells extending through fresh water strata into mineralized water formations.

(b) Financing plugging of abandoned wells, or other perforations, penetrating mineralized water formations for which individual or corporate responsibility can no longer be established.

(c) Obtaining disposal well sites for oil and gas well brine production.

Oklahoma

It is recommended that:

(1) Appropriate agencies be granted necessary authority and funds to accurately define the extent of pollution from natural sources in the Cimarron River Basin and to thoroughly study possible abatement or control measures.

(2) Adequate authority and personnel be provided to responsible agencies for effective control of brine pollution from oil fields developed prior to 1937, and for development in cooperation with the industry, of practical brine disposal methods and facilities.

(3) An intensified program to reduce the effects of chemical pollution from industrial sources be initiated by responsible agencies, in cooperation with industry, prior to construction of the authorized Keystone Reservoir.

(4) The programs of agencies concerned be expanded to provide for more frequent inspection of waste treatment and disposal facilities and to increase activities for training of plant operators, particularly for operators of small municipal and industrial waste treatment plants.

(5) Public educational programs sponsored by State water pollution control agencies be expanded to publicize the value of water resources to the basin, existing damages due to pollution, and the necessity for conservation and protection of water resources for maximum economic development within the basin.

(6) Responsible State water pollution control agencies review existing pollution legislation for the purpose of recommending amendments to facilitate equitable enforcement.

(7) Routine programs of pollution control agencies be expanded to accelerate correction of existing deficiencies in municipal and industrial waste disposal facilities.

DESCRIPTION

General

The Cimarron River rises in the Johnson Mesa area of northeastern New Mexico and flows generally eastward to its junction with the Arkansas River about 17 miles above Tulsa, Oklahoma. The headwaters portion of the stream, in New Mexico, is called the "Dry Cimarron River" to distinguish it from another Cimarron River which is tributary to the South Canadian River.

The river basin is over 600 miles in length and has a drainage area of about 19,000 square miles, of which 1,150 are in New Mexico; 2,100 are in Colorado; 6,450 are in Kansas and 9,300 in Oklahoma. The principal tributary is the North Fork, which rises in Colorado and joins the Cimarron River near Satanta, Kansas. Other important tributaries are Crooked, Kingfisher, Cottonwood and Stillwater Creeks.

The stream flows from its source near Capulin Mountain in New Mexico eastward into Oklahoma and then crosses the extreme southeastern corner of Colorado and the southwestern corner of Kansas. It returns to Oklahoma at a point near Forgan, Oklahoma, and follows generally the Kansas-Oklahoma State line eastward for a distance of about 75 miles. From a point near Buffalo, Oklahoma, the river flows in a southeasterly direction across Oklahoma to its mouth.

Topography and Geology

The "Dry" Cimarron River in New Mexico drains mountains and plateaus with a maximum altitude of 8,000 feet. The altitude of the river channel at the New Mexico-Oklahoma line is 4,600 feet. In New Mexico the river flows in a narrow canyon eroded in sandstones except for a few wider valleys. In Oklahoma the canyon widens into a valley about two miles in width and 60 miles in length, which extends into Kansas. At a point near Feterita, Kansas, the channel narrows and for an additional 60 miles the river bed resembles that of a small dry creek. Little water passes this reach, except in periods of extreme flood conditions. This dry stretch marks the division between the upper and lower rivers. Only the continuous channel indicates that the river should be considered a single stream. Topography of the upper reach of the watershed is generally broken and rough.

At a point north of Liberal, Kansas, water reappears in the stream channel and the flow gradually increases downstream. In places deep ravines have been cut in red beds and in northwestern Oklahoma the river passes through heavy gypsum and rocksalt deposits. Salt plains have developed on both sides of the river as a result of discharges from large salt water springs in Woods and Harper Counties, Oklahoma. The 250 miles of the river channel is sandy and broad, averaging about three fourths of a mile in width.

Climate and Hydrology

The western portion of the basin is semi-arid and is characterized by low relative humidity, wide seasonal temperature changes, and poor rainfall distribution. The lower third of the basin has a more humid climate and

better rainfall distribution. Precipitation in the upper area is about 16 inches annually; there is a general increase eastward to the mouth of the river where the annual average is about 38 inches. Mean annual rainfall over the entire basin is about 23 inches.

Most of the tributaries of the Cimarron River are dry creeks except during torrential rains. Except for the North Fork and Crooked Creek, they are short with small drainage areas. Runoff characteristics of the river are extremely erratic because of the variable climatic and physiographic conditions within the long, narrow watershed. In general, flow of the Cimarron River along its entire length is characterized by its irregularity, varying from short periods of high flow to long periods of low or zero flow.

Flood flows originating in the headwaters and central portions of the watershed are generally absorbed in wide, sandy sections of the stream channel and rarely contribute to downstream flooding. The lower section of the river, from Kingfisher, Oklahoma, to the mouth (140 miles), is the principal flood producing portion of the watershed. Rainfall is heavier and more frequent in that area and the river flood plain is narrow and well defined.

Recorded average, maximum and minimum stream flows at various gaging stations are tabulated below:

Gaging Station	Period of Record (Years)	Drainage Area (Sq. mi.)	Daily Flow (cfs) Average	Maximum	Minimum
Near:					
Guy, New Mexico	8	545	12*	7,120	0.0
Boise City, Oklahoma	10	1,955	83*	80,000	0.0
Mocane, Oklahoma	8	8,653	146*	10,500	0.0
Waynoka, Oklahoma	12	13,307	425	70,000	0.0
Guthrie, Oklahoma	12	16,865	929	51,500	0.1
Perkins, Oklahoma	11	17,825	1,297	65,300	1.0
At Mannford, Oklahoma	11	18,822	1,711	103,000	5.0

*Water year 1949-50 only.

Upper Cimarron River water is used primarily for irrigation purposes. Erratic flow and highly mineralized water in the lower main stem of the river preclude use of Cimarron River water for higher purposes. Some of its tributaries provide water of satisfactory quality and are used as sources of municipal water supply in the lower part of the basin.

Alluvium underlies the flood plain of the river and it yields, in places, large quantities of water of fairly satisfactory quality. However, ground water is usually highly mineralized. In the Kansas portion of the basin practically all water supply is obtained from the gravels underlying the High Plains area or from alluvial deposits. The major alternate source of ground water supply in Oklahoma is terrace deposits although several other aquifers have been developed as sources of municipal water supply.

Population

The 1950 population of the basin was approximately 217,000, about 70 percent of which was in Oklahoma. The principal cities are Enid (36,017), Stillwater (20,238), Guthrie (10,113), Cushing (8,414), Drumright (5,028) and Kingfisher (3,345), Oklahoma. Liberal (7,136), Kansas and Springfield (2,044), Colorado are major population centers in the upper portion of the basin.

Industry and Land Use

Farming and stock raising are the major land uses in the basin. In the western two-thirds of the basin farming is limited to drought resistant crops although irrigation is practiced in New Mexico and other areas when sufficient water is available. Most of the land area is utilized as range land for cattle. The best farm lands in the basin lie in the lower 200 miles and there is generally sufficient rainfall in this region to support successful farming without irrigation.

There are no significant industrial developments in the New Mexico and Colorado portions of the basin. The extensive Hugoton gas field is the basis for gasoline and carbon black production in Kansas. The basin downstream from Waynoka, Oklahoma, is a major oil producing area. Industrial development of other types is extremely limited.

USES OF WATER RESOURCES

The principal uses of water resources in the Cimarron River Basin are for municipal water supply and agricultural uses, including stock and irrigation water. Erratic and limited flow throughout the basin and the inferior chemical quality of river water in the lower basin preclude most uses of surface water. Ground water supplies are generally limited in quantity and are highly mineralized except for the High Plains area of Kansas and the Oklahoma Panhandle.

The Cimarron River is not used as a source of municipal water supply in any part of the basin. The three surface water sources of municipal supply have been developed on tributary streams in the lower basin. The remaining sixty-one public water supplies and practically all industrial supplies have been developed from ground water sources.

The total of 64 community water supplies in the basin serve a population of about 135,600. Average daily consumption from all basin municipal supplies is 13.5 million gallons. Basic data concerning public water supplies are summarized in Table 1. Existing primary surface water uses in the basin are on Map No. 1.

Significant water use information for each of the State areas comprising the basin is outlined below:

New Mexico

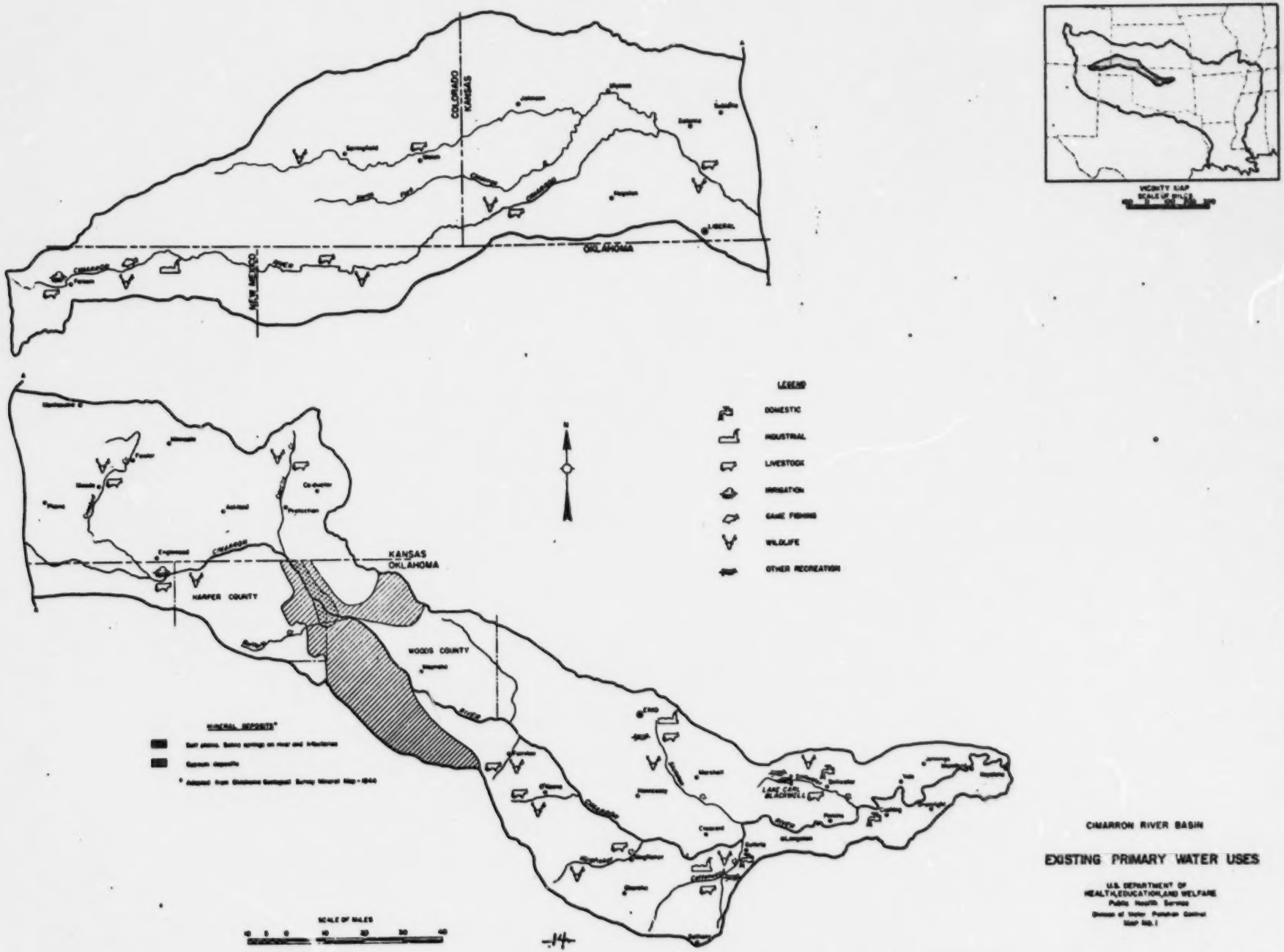
The major use of basin water resources in New Mexico is for irrigation purposes in connection with the operation of large livestock ranches. Several thousand acres of land are irrigated in the Black Mesa and Folsom areas by diversions from the Cimarron River. The principal irrigated crops are alfalfa and vega hay. Additional land is physically suitable for sustained irrigation and this use of water resources is likely to increase in the future if such projects as the proposed Baker Reservoir are constructed. Development of surface water resources will be necessary because ground water reservoirs are not capable of supporting irrigation requirements.

There are no existing municipal water supplies in the New Mexico portion of the basin. Individual household domestic and stock water supplies are derived from ground water sources which yield limited quantities of highly mineralized water.

Water supply, for present uses, is not a serious problem in the New Mexico part of the basin because of very low population concentration and negligible industrial development.

Colorado

All basin municipal and rural domestic and stockwater supplies in Colorado have been developed from ground water sources. Suitable ground water is generally limited in quantity and is highly mineralized. Major land uses are for grazing and dry farming because water required for extensive irrigation is not available. There are no significant industrial



CIMARRON RIVER BASIN

EXISTING PRIMARY WATER USES

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Pollution Control
Map No. 1

TABLE 1

CIMARRON RIVER BASIN
MUNICIPAL WATER SUPPLIES

Municipality	Estimated Population Served	Average Output m.g.d.	Average Consumption g.p.c.d.	Treatment	Source	Plant Capacity m.g.d.	Remarks
			Supplies from ground water sources				
COLORADO							
Campo	240	0.012(E)	50(E)	None	Deep well		
Pritchett	280	0.014(E)	50(E)	None	2 deep wells	2.0	
Springfield	2,000	0.300	150	None	6 deep wells	1.0	
Two Buttes	40	0.002(E)	50(E)	None	Deep well	-	
Walsh	720	0.036(E)	50(E)	None	Deep wells	0.25	
(5)Total (Colorado)	3,280	0.364(E)					
KANSAS*							
Ashland	1,200	0.20	165	D	Shallow well	0.78	
Coldwater	950	0.15	160	D	Shallow wells	0.72	
Copeland	190	0.05	260	None	Deep well	0.14	
Englewood	300	0.20	670	D	Shallow wells	1.01	
Fowler	400	0.15	375	None	Deep wells	1.01	
Hugoton	1,100	0.13	120	D	Deep wells	0.54	
Johnson City	450	0.10	220	None	Deep wells	0.56	
Kismet	120	0.02	165	None	Deep wells	0.10	
Liberal	6,000	1.50	250	D	Deep wells	3.13	
Manter	100	0.01	100	None	Deep wells	0.22	
Meade	1,000	0.40	400	D	Deep well	1.01	
Minneola	400	0.08	200	None	Deep wells	0.40	
Montezuma	300	0.07	235	None	Deep well	0.29	
Moscow	100	0.01	100	None	Deep well	0.07	
Plains	500	0.03	60	None	Deep well	0.50	

Municipality	Estimated Population Served	Average Output m.g.d.	Average Consumption g.p.c.d.	Treatment	Source	Plant Capacity m.g.d.	Remarks
KANSAS cont'd							
Protection	700	0.11	155	None	Shallow wells	1.30	
Rolla	230	0.04	175	None	Deep wells	0.36	
Satanta	300	0.05	165	None	Deep wells	0.57	
Sublette	500	0.10	200	None	Deep wells	0.88	
Ulysses	2,000	0.80	400	D	Deep wells	1.73	
(20)Total (Kansas)	16,840	4.20					
NEW MEXICO	(There are no community water supplies within the basin in New Mexico)						
OKLAHOMA**							
Aline	390	0.010	26	D	Shallow wells	0.075	2 wells (35 ft. deep)
Avard	100	0.005(E)	50(E)	D	Spring	--	
Buffalo	1,650	0.083(E)	50(E)	None	5 Springs	--	Aquifer - Ogallala formation
Carmen	670	0.034(E)	50(E)	None	Shallow wells	1.95	5 wells (30 ft. deep) Probable aquifer - El Reno formation
Covington	770 1/	0.039(E)	50(E)	D	Deep and shallow wells	0.24	7 wells (40-185 ft. deep) aquifer - Garber and Wellington formations
Coyle	360	0.018(E)	50(E)	None	Shallow wells	0.12	1 well (40 ft. deep) Aquifer-alluvium
Crescent	1,340	0.067(E)	50(E)	None	Shallow wells	0.50	3 wells (55 ft. deep) Aquifer-terrace deposits
Drumright	5,400	0.400(E)	75(E)	D	Deep wells	0.58	7 wells in Tiger Creek watershed. Aquifer - Nelagoney and Vamoosa formations
Edmond	6,190	0.620	100	None	Deep wells	2.59	6 wells (440-740 ft. deep) in Chisholm Creek watershed

1/ Supply from Arkansas River Basin

Municipality	Estimated Population Served	Average Output m.g.d.	Average Consumption g.p.c.d.	Treatment	Source	Plant Capacity m.g.d.	Remarks
OKLAHOMA cont'd							
Enid	36,040	2.500	70	D	Shallow wells	7.40	42 wells (25-75 ft. deep) Aquifer - Terrace deposits
Fairview	2,450	0.123(E)	50(E)	None	Shallow wells	1.73	4 wells (35-60 ft. deep) Aquifer - Terrace deposits
Forgan	410	0.050	120	D	Shallow wells	0.20	3 wells (70 ft. deep) Aquifer-Ogallala formation
Freedom	330	0.017(E)	50(E)	None	Shallow well	0.07	1 well (30 ft. deep)
Gate	200	0.010(E)	50(E)	D	Shallow wells	--	2 wells (50 ft. deep) Aquifer-Ogallala formation
Goltry	280	0.014(E)	50(E)	None	Shallow wells	0.23	4 wells (35 ft. deep)
Hallett	120	0.006(E)	50(E)	None	Deep wells	0.04	2 wells (300 ft. deep)
Helena	485	0.024(E)	50(E)	D	Shallow wells	1.00	3 wells (50 ft. deep) Probable aquifer-El Reno
Hennessey	1,300	0.065(E)	50(E)	None	Shallow wells	0.43	3 wells (60 ft. deep) Aquifer - Terrace deposits
Hitchcock	190	0.010(E)	50(E)	None	Spring	--	
Jennings	350	0.018(E)	50(E)	None	Deep Wells	--	2 wells (300 ft. deep) Probable aquifer - Elgin formation
Kingfisher	3,350	0.300	90	ACFSD	Shallow wells	0.86	4 wells (30 ft. deep) Probable aquifer - Cimarron River alluvium
Langston University (Including City of Langston)	1,900	0.095(E)	50(E)	D	Shallow wells	0.27	2 wells (25-40 ft. deep) Aquifer - Wellington Formation
Longdale	290	0.015(E)	50(E)	None	Shallow well	0.08	1 well (70 ft. deep)
Mannford	630	0.031(E)	50(E)	D	Shallow wells	--	3 wells (90 ft. deep) Aquifer - Nelagoney and Vamoosa formations
Marshall (New)	320	0.016(E)	50(E)	D	Shallow wells	--	2 wells (45 ft. deep) Aquifer-Garber and Wellington Formations

Municipality	Estimated Population Served	Average Output m.g.d.	Average Consumption g.p.c.d.	Treatment	Source	Plant Capacity m.g.d.	Remarks
OKLAHOMA cont'd							
Mulhall	260	0.013(E)	50(E)	D	Shallow well	0.04	1 well (45 ft. deep) Aquifer-Garber and Wellington Formations
Oilton	1,000	0.050(E)	50(E)	D	Deep wells	--	5 wells (300 ft. deep) Aquifer-Nolagoney and Vamoosa formations
Okarche	570	0.029(E)	50(E)	D	Shallow wells	0.08	3 wells (40 ft. deep)
Okeene	1,210	0.061(E)	50(E)	D	Shallow wells	0.65	3 wells (50 ft. deep) Aquifer-Terrace deposits
Perkins	770	0.020	26	D	Shallow wells	0.32	2 wells (80 ft deep) Probable aquifer - alluvium
Quinlan	115	0.006(E)	50(E)	None	Deep wells	0.05	5 wells (170 ft. deep)
Ripley	290	0.015(E)	50(E)	D	Shallow wells	0.13	2 wells (40 ft. deep) Probable aquifer - alluvium
Southard	500	0.025(E)	50(E)	D	Shallow wells	0.32	2 wells (60 ft. deep) Probable aquifer - terrace deposits
Waukomis	540	0.027(E)	50(E)	D	Wells	0.17	
Waynoka	1,950	0.098(E)	50(E)	D	Shallow wells		4 wells (70 ft. deep) Aquifer-Terrace deposits
Yale	1,500	0.100	67	D	Shallow wells	--	5 wells (45 ft. deep) some water from other sources. Aquifer - alluvium
(36) Total	74,220	5.014					
	(Supplies from surface water sources)						
COLORADO	(There are no municipal water supplies in the basin derived from surface sources)						
KANSAS *	(There are no municipal water supplies in the basin derived from surface sources)						
NEW MEXICO	(There are no municipal water supplies in the basin derived from surface sources)						
OKLAHOMA**							
Cushing	9,830	1.210	125	CFD	Big Creek impoundment at Cushing City Lake (cap.-4,570 ac/ft)	3.0	

TABLE 1 cont'd — Sheet 5 of 5

Municipality	Estimated Population Served	Average Output m.g.d.	Average Consumption g.p.c.d.	Treatment	Source	Plant Capacity m.g.d.	Remarks
OKLAHOMA cont'd							
Guthrie	10,300	0.705	70	CFDT	Tributary to Cottonwood Creek impounded at Lake Guthrie (cap.2,250 ac/ft)	2.0	
Stillwater	21,150	2.140	100	ACFSDT	Stillwater Creek impounded at Lake Carl Blackwell (Cap. 55,000ac/ft)	Capacity City plant 4.0	Total capacity of City and A & M College plants 5.5 m.g.d. Water purchased from college since 1950.
(3) Total (Oklahoma)	41,280	4.055					

Treatment Code: A - Aeration C - Coagulation and sedimentation D - Disinfection
F - Filtration S - Softening T - Taste and odor control

Data abstracted from:
* "Inventory of Water and Sewage Works in Kansas" (1950), Division of Sanitation, Kansas State Board of Health.
** "Public Water Supplies in Oklahoma"(1951) USGS in cooperation with Oklahoma Planning and Resources Board

(E) Estimated. (Very few reliable records of pumpage are available, particularly for the smaller towns).

developments in the Colorado portion of the basin.

While water supply is not a serious immediate problem in the Cimarron River Basin area of Colorado, the limited availability of water severely restricts future development.

Five public water supplies in the basin serve about 3,300 persons. Average daily water consumption is estimated at 360,000 gallons. Additional data are summarized in Table 1.

Kansas

The major water resource of the Kansas and Oklahoma Panhandle portions of the Cimarron River Basin is a very large ground water reservoir underlying the High Plains area. In this area, which includes most of the basin in Kansas, all municipal, industrial, rural domestic and stock water and nearly all irrigation water is pumped from that source. The supply is considered adequate in quantity for all existing uses and for considerable future development as a source of irrigation water. The water is relatively hard but otherwise of very good quality. This source of supply is not available in the eastern part of the Kansas Basin and other aquifers, including alluvial deposits, have been developed.

The Cimarron River is not directly used as a source of water supply in Kansas except, to a limited extent, for irrigation. Possibly the most important function of the river is as a source of recharge for the High Plains ground water reservoir.

Industrial use of water in the Kansas portion of the basin is largely confined to cooling waters used by eight major plants processing natural gas from the Hugoton Field and to the requirements of railroad watering stations. Most large industrial supplies are privately developed from ground water sources. Small industries are usually served by municipal supplies.

All basin municipal supplies are derived from ground water sources. A total of 20 public supplies serve a population of about 16,800 with approximately 4.2 million gallons of water daily. Data concerning basin municipal supplies are summarized in Table 1. Information on chemical quality is provided in Table 2a of the Appendix.

In general, water supply in the Kansas part of the basin is not a serious problem and in most localities is adequate for considerable further development.

Oklahoma

With the exception of the Panhandle section, the Cimarron River in Oklahoma is too heavily polluted from natural and industrial sources for any continuous use in which water quality is significant.

The three municipal surface water supplies in the basin have been developed on tributaries of the river by Cushing, Guthrie and Stillwater, Oklahoma. Another reservoir, serving Oklahoma City, is located in the basin but the water impounded is diverted from the North Canadian River. The three

surface supplies utilizing basin water resources serve a total population of about 41,300 and provide an average of 4.05 million gallons of water daily.

Thirty-six Oklahoma communities in the basin have ground water supplies developed from several different aquifers, including river alluvium. Ground water supplies serve a total population of about 74,200. Average water consumption is about 5.0 million gallons daily. Enid, Oklahoma, is the principal city served by a ground water source. Its supply, from terrace deposits, is satisfactory with respect to quality but inadequate in quantity. The city is actively planning to develop a supplementary source. The ground water supplies vary widely both as to quality and sustained water yield.

Data concerning municipal water supplies are summarized in Table 1. Information on quality of municipal supplies is shown in Table 2a of the Appendix.

Considerable acreage is irrigated in the Oklahoma part of the basin, primarily from ground water sources. About 5,000 acres have been irrigated in Harper County by diversion of Cimarron River water at a point near Englewood, Kansas, which is upstream from the salt plains in Harper and Woods Counties, Oklahoma. Down stream from the salt plains the quality of river water is rarely suitable for irrigation or any other higher purpose.

The major industrial water users in the Oklahoma Basin are the oil refineries, each of which may require about 1.5 million gallons daily for all purposes. In most cases, refinery supplies are privately developed from ground water sources. There is considerable industrial development in the larger cities in the basin, such as Enid and Guthrie. In general, the industries located in the cities secure water from municipal supplies but frequently have stand-by or supplementary supplies, usually from ground water sources.

There are no existing impoundments on the main stem of the Cimarron River in Oklahoma. The only project which has been authorized which would directly affect the basin is the Keystone Reservoir on the Arkansas River just downstream from the mouth of the Cimarron. There are several existing reservoirs on tributaries and others have been proposed which would permit greater utilization of the surface water resources of the basin. Two main stem reservoir projects have been proposed for the Cimarron River in Oklahoma. One, the Castenada project in Cimarron County, would impound water of fairly satisfactory quality for such purposes as irrigation. The other, near Crescent, Oklahoma, would impound water of unsatisfactory quality for most higher uses, but could be utilized to provide additional recreational facilities in the basin.

In summary, the main stem of the Cimarron River is a resource of very limited value in the lower reach of the basin in Oklahoma because of excessive chemical pollution from natural and industrial sources. The effect of such pollution on the chemical quality of river water is summarized in Table 3a of the Appendix. Some tributaries of the river provide water of satisfactory quality but flow is relatively small. The most important basin water resource, in terms of number of communities served, is ground water from several aquifers yielding widely variable quantities and qualities of water. Very few alternate sources of water supply are available in any part of the basin in Oklahoma. For that reason conservation and protection of existing supplies is extremely important.

POLLUTION CONTRIBUTED TO WATER RESOURCES

Pollution contributed to the water resources of the basin may be listed in three general categories:

1. Municipal pollution - Sewage and industrial waste discharged from public sewer systems.

2. Industrial pollution - Industrial process wastes discharged directly to watercourses through separate outlets. (Such wastes, in the Cimarron River Basin, are almost exclusively oil field brines and oil refinery process wastes.)

3. Natural pollution - Sediment from land erosion and solution of mineral salts by waters passing over or through natural deposits of salt, gypsum and other soluble materials.

A total of 41 municipalities in the basin have community sewerage facilities. The degree of treatment provided and the relative amount of residual pollution discharged to the Cimarron River and its tributaries, after the degree of treatment provided, is summarized in the following tabulation:

State	Population Served	Treatment Provided (Number of Communities) None	Primary	Secondary	Population Equivalent Discharged to Watercourse	Percent Reduction
New Mexico	None	0	0	0	None	----
Colorado	2,400	0	2	0	1,350	43.5*
Kansas	21,000	0	1	13	2,500	88.0*
Oklahoma	102,400	2	7	16	40,200	60.6
Total	125,800	2	10	29	44,050	65.0

*One Colorado community and three Kansas communities dispose of treated sewage by seepage and evaporation without discharge to any watercourse.

Industrial waste is not a general problem in the basin. For that reason industrial pollution is discussed separately under the headings of the four State areas included in the basin.

The erratic runoff characteristics of the Cimarron River Basin create a difficult silt control problem throughout the basin. The following tabulation, adapted from information provided by the Corps of Engineers, U. S. Army, indicates the degree of pollution of this type:

Location	River Miles Above Mouth **	Drainage Area (Sq. mi.)	Annual Quantities of Silt (Acre Feet*)	Remarks
Cimarron River				
Near Boise City, Okla.	C 550	1,955	1,760	0.9 acre ft/sq. mi.
At Mannford, Okla.	C 10	18,822	6,180	0.33 acre ft/sq. mi.
Arkansas River				
At Ralston, Okla.	A 594	54,227	7,100	Above Cimarron River
At Tulsa, Okla.	A 515	74,350	15,000	Below Cimarron River

*Based on 70 pounds per cubic foot
**C - Cimarron River
A - Arkansas River

It will be noted that the silt contribution of the Cimarron River, according to these estimates, represents about 41.2 percent of the silt content of the Arkansas River at Tulsa, Oklahoma, although the Cimarron River Basin represents only 25.3 percent of the drainage area of the Arkansas River at that point.

The causes and effects of water pollution are so widely variable in different parts of the basin that they are hereafter discussed separately under the headings of the four State areas included in the basin:

New Mexico

There are no existing municipal or industrial sources of pollution in the New Mexico portion of the basin. The only pollution of appreciable magnitude likely to be contributed in this area would be highly mineralized irrigation return water. There is, however, no indication that water pollution is, at present, a serious problem in this part of the basin.

Colorado

There are no industrial sources and only two municipal sources of pollution in the basin area of Colorado. Both municipalities provide treatment facilities and one disposes of waste by seepage and evaporation without discharge to a watercourse. Some community water supplies are highly mineralized by natural sources of pollution. However, pollution is not a critical factor affecting water uses in the Colorado portion of the basin.

Kansas

The Kansas portion of the basin is primarily an agricultural area but there is considerable industrial development based on the processing of natural gas from the Hugoton gas field. Eight major plants manufacture gasoline, carbon black and related products. Under satisfactory operating conditions the principal waste discharge from such plants is cooling water and it

is understood that they do not constitute significant sources of pollution.

There are 14 municipal sources of pollution in the Kansas Basin representing a total population served by sewer systems of about 21,000. Twelve communities provide secondary waste treatment; two have primary treatment only. Pollution discharged to the Cimarron River is further limited because three communities, representing a total population served of 10,400, dispose of treated waste, by seepage and evaporation, without discharge to any watercourse.

A very large acreage in the Kansas portion of the basin is physically suitable for irrigation with water from the High Plains ground water reservoir. Highly mineralized irrigation return water is a potential source of considerable chemical pollution.

Oklahoma

The most important sources of pollution of the Cimarron River, of all types, are in the lower reach of the basin in Oklahoma. From a water use point of view the most critical problem is chemical pollution from natural and industrial sources. The magnitude of pollution of this type is indicated by the chemical analyses summarized in Table 3a of the appendix and the following tabulation:

Stream and Location	Mean Discharge		Weighted Average Chloride Content		
	(cfs)	Percent of Total*	(ppm Cl)	Tons Daily (As NaCl)	Percent of Total*
Arkansas River At Ralston, Okla.	6,819	73.2	240	7,280	33.8
Cimarron River At Mannford, Okla.	2,090	22.4	1,100	10,300	47.2
Arkansas River At Sand Springs, Okla.	9,315	100.0	523	21,500	100.0

*Percent of total at Sand Springs, Oklahoma.

Notes: 1. Ralston, Oklahoma, is upstream from the junction of the Arkansas and Cimarron Rivers and Sand Springs a few miles downstream. The Cimarron River is the only major tributary between these points on the Arkansas River.

2. The data shown above is adapted from continuous daily flow and water quality measurements, over the period from January to October, 1950, obtained for and published by the Oklahoma Planning and Resources Board. This is the only period for which daily concurrent measurements are available for the three stations.

It will be noted that, for the only available period of record, the Cimarron River contributed nearly 50.0 percent of the chemical pollution, as

measured by chloride content, of the Arkansas River at Sand Springs and more than all sources of chemical pollution on the Arkansas River, upstream from Ralston, Oklahoma, combined.

The analyses at the Mannford, Oklahoma, gaging station represent the combined effect of both natural and industrial pollution. Sufficient data to accurately define the relative contribution from natural and industrial sources are not available. However, each source represents a very substantial proportion of the total chemical pollution.

The major sources of natural pollution are gypsum and rocksalt deposits and salt springs in Woods and Harper Counties, Oklahoma, near the Kansas State Line. Locations of these sources are indicated on Map Number 2.

Important industrial sources include four oil refineries and seven major oil field areas which do not provide adequate waste disposal facilities. These sources are also located on Map Number 2. There are also seven gasoline plants and two waste oil reclamation plants in the basin but they are not considered significant sources of pollution.

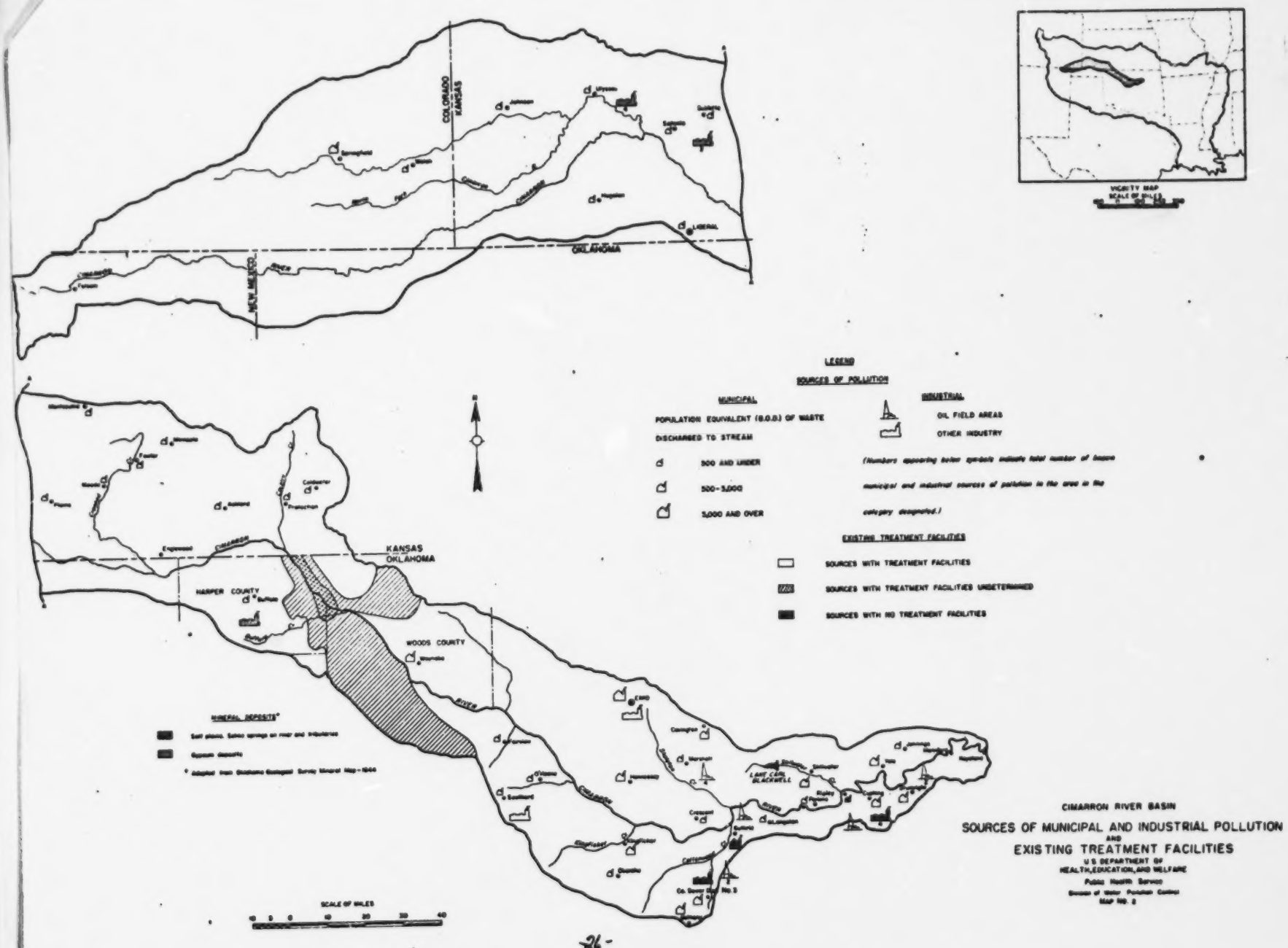
The potential pollutional effect of oil field brines, and the necessity for adequate brine disposal, is shown by the chemical analyses of typical brines included in Table 4a of the Appendix. It will be noted that the average values represent a salt content (calculated as NaCl) of nearly 70 pounds of salt per 42 gallon barrel or about 835 tons per million gallons (23,800 barrels) of brine.

There are 25 municipal sources of pollution in the Oklahoma part of the Cimarron River Basin representing a total population served by sewer systems of 102,400. Pollution discharged to basin watercourses, after the degree of treatment provided, is estimated to be equivalent to the untreated waste of a population of 40,200.

Summaries of data concerning municipal and industrial sources of pollution in Oklahoma are shown in Tables A and B. Table 1a of the Appendix is a detailed summary of data on sources of municipal pollution. Map Number 2 shows the locations of sources of municipal, industrial and natural pollution and existing treatment facilities.

The chemical quality of Cimarron River water at Mannford, Oklahoma, is indicated in Table 3a of the Appendix. The average quality and, particularly, variations in maximum and minimum values indicate that extensive pollution control measures will be required to reclaim river water for any higher purpose.

Serious natural and industrial pollution of the Cimarron River originates almost exclusively in the Oklahoma portion of the basin and represents an extremely difficult pollution control problem for all water conservation and pollution control agencies concerned.



CIMARRON RIVER BASIN

SOURCES OF MUNICIPAL AND INDUSTRIAL POLLUTION AND EXISTING TREATMENT FACILITIES

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Pollution Control
MAP NO. 2

TABLE A
SOURCES OF POLLUTION
MUNICIPAL

Municipalities*	Sources of Pollution (In Number of Municipalities)		Population Served by Sewerage System	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People)
Having data on pollution load discharged to watercourse	Colorado	2	2,400	1,350
	Kansas	14	21,000	2,500
	New Mexico**	0	0	0
	Oklahoma	25	102,400	40,200
Having population data available (Data on pollution load to watercourse incomplete or not available)	----		----	----
TOTAL		41	125,800	44,050

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers; sanitary sewage wastes discharged by industry directly into watercourse and industrial wastes discharged into municipal sewage systems.

**There are no sources of municipal pollution in the New Mexico portion of the basin.

TABLE B
SOURCES OF POLLUTION
INDUSTRIAL

Industries*	Sources of Pollution (In Number of Plants)		Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People)
Producing Organic Wastes	Oklahoma	5	Undetermined
Producing Organic Wastes			
Producing Inorganic Wastes	Oklahoma	14	xxx
Producing Wastes of Undetermined Type	Oklahoma	3	Undetermined
	Oklahoma #	19 **	

* Industries having separate outlets discharging directly to watercourses.

** Total adjusted for 4 plants producing both organic and inorganic wastes.

Note: There are no significant waste producing industries in the New Mexico and Colorado portions of the basin.

Several carbon black and gasoline plants in the Kansas Basin are not tabulated because they are not significant sources of pollution under normal operating conditions.

DAMAGES TO WATER RESOURCES FROM POLLUTION

Damages to water resources in the basin must be considered in two general categories, namely, the existing or specific damages and the potential damages which may result from pollution. Existing damages to water resources from pollution are limited in the New Mexico, Colorado and Kansas portions of the basin. Existing damages to water resources in the Oklahoma part of the basin due to pollution are definite and severe. Specific and potential damages in the four State areas comprising the basin are discussed separately below.

New Mexico

There are no existing sources of municipal or industrial pollution in the New Mexico Basin area. Ground water supplies are affected to some extent by natural mineral deposits but pollution cannot be considered a factor limiting any existing water use.

Colorado

Water resources in the Colorado part of the basin are not affected by industrial pollution and damage due to the two municipal sources of pollution is limited and localized. Ground water supplies are relatively hard but limited availability is a considerably more serious problem than pollution of any type.

Kansas

Industrial waste in the Kansas Basin, under existing conditions, has not created serious pollution problems. Eleven of the fourteen sources of municipal pollution in the Kansas Basin provide secondary treatment in plants of adequate capacity. The principal sources of water supply are ground water reservoirs and there is no indication that pollution has yet seriously damaged water uses. Potentially, pollution of any type, in the Cimarron River may damage such resources because the river serves to recharge the High Plains ground water reservoir and pollution of the river would also affect water quality in the river alluvium.

Oklahoma

The lower reach of the Cimarron River, from Woods and Harper Counties, Oklahoma, at the Kansas State line to the mouth, has been damaged to such an extent by chemical pollution that river water is usable only for purposes for which water quality has no significance. In fact, the river is so heavily polluted by mineral salts that it seriously affects the quality of Arkansas River water for reasonable downstream uses. The quality of water impounded in the proposed Keystone Reservoir will depend largely on the degree of control established over chemical pollution in the Cimarron River. It has been stated above that the weighted average chloride content of Cimarron River water for a nine month period of record represented nearly 50.0 percent of that in the Arkansas River at Sand Springs, Oklahoma, for the same period. Similar data (Water year 1946-47) indicate that the Cimarron River may contribute more than one third of the total chloride content of Arkansas River water as far downstream as Little Rock, Arkansas.

Although the Cimarron River is not directly used for water supply purposes in the basin, its alluvium is a source of supply for six municipalities and probably many individual domestic and stock water supplies in Oklahoma. River pollution may seriously affect the quality of such supplies.

Polluted waters used for livestock watering present a definite hazard to that important basin resource. While it is unlikely that the types of pollution discharged into the Cimarron River would cause serious direct losses of livestock, it is known that development of livestock is inhibited and that actual losses have been reported where animals were exposed to grossly polluted water. Basin wildlife would also be adversely affected.

The Cimarron River Basin is not a highly developed recreational area and fish life is a minor resource because of erratic river flow and polluted water. However, there are fish in the river and its tributaries at times. At least ten cases of stream pollution causing fish destruction have been prosecuted by the Oklahoma Department of Game and Fish in the lower reach of the basin since 1948.

Untreated and inadequately treated domestic sewage creates local health hazards and nuisance conditions in the lower reach of the basin. Unsatisfactory disposal of oil field brine, in particular, represents a constant threat to the quality of any ground water source underlying the brine disposal area. Damage to any ground water source of supply is especially important because of the very limited number of alternate sources of supply available to the numerous communities and individuals in the Oklahoma Basin using ground water.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

It can be stated generally that all water uses derive some degree of benefit from a program of water pollution control. In some cases benefits can be evaluated on a monetary basis but most benefits related to public health, protection of water supplies, preservation of aquatic life, maintenance of recreational facilities and prevention of public nuisance cannot be assigned a specific value. Nevertheless, benefits of both types provide real justification for pollution prevention and abatement within the basin.

Prevention of the relatively serious silt pollution problem throughout the basin requires control of soil erosion and represents preservation of a valuable agricultural resource as well as protection of water resources.

Benefits to be derived from pollution control are directly related to existing and potential damages due to pollution. Since both damages due to pollution and advantages to be expected from pollution control vary in the four State areas included in the basin, they are discussed separately as follows:

New Mexico and Colorado

Water pollution is not a serious problem in the New Mexico and Colorado portions of the basin because of the very limited number of sources and minor degree of pollution involved. Consequently, benefits from pollution control are correspondingly limited.

Kansas

In the Kansas part of the basin pollution of the Cimarron River or its tributaries represents possible serious damage to the quality of major and irreplaceable ground water supplies. The most important benefit to be derived from pollution control is continued protection of those supplies. Supplementary benefits include prevention of health hazards and local nuisances due to municipal waste discharges and preservation of the rather limited direct uses of the Cimarron River in the Kansas portion of the basin.

Oklahoma

The most serious damage to water resources due to pollution occurs in the lower reach of the basin in Oklahoma. Chemical pollution in this area is of such a magnitude that it has not only destroyed the Cimarron River for most water use purposes but also adversely affects reasonable uses of the Arkansas River. It is questionable that practical pollution control measures can improve the chemical quality of Cimarron River water to such an extent that it will be satisfactory for water uses in which good quality is a requirement. However, control of pollution would have a beneficial effect on the quality of water supplies derived from river alluvium and on the quality of Arkansas River water downstream from the junction of the two rivers.

Other benefits of pollution control include prevention of health hazards and nuisances due to municipal waste discharges.

Very few alternate sources of water supply are available in the Oklahoma part of the basin. Protection of existing sources of water supply is vital to the economic development of the area. Continuous control of chemical pollution is necessary to protect existing ground water supplies in river alluvium and other aquifers.

POLLUTION PREVENTION MEASURES IN EFFECT

New Mexico

No specific pollution control measures are in effect in the New Mexico portion of the basin because of the absence of significant sources of municipal or industrial pollution.

General measures applicable to the New Mexico Basin include the rules and regulations of the State Board of Public Health and the permit authority of the State Engineer. The Board of Health is the responsible agency so far as public health is concerned and has been designated the State water pollution control agency under the Federal Water Pollution Control Act. The State Engineer has general supervision of waters of the State and must issue a permit to applicants for rights to beneficial use of such waters. Permits may be denied when the water use is considered contrary to the public interest.

Colorado

There are no significant sources of industrial pollution in the Colorado Basin. The two municipalities having sewerage systems have provided primary treatment facilities for a total population of about 2,400. One plant, serving a population of 360, is considered adequate in capacity for present needs. The plant serving the other municipality (Springfield, Colorado) should be replaced. Additional data regarding the plants are summarized in Table C and Table 1a of the Appendix. Plant locations are shown on Map No. 2.

General pollution control measures are administered by several different agencies. The Department of Health has broad powers related to public health aspects of water pollution and the Game and Fish Department is authorized to control waste discharges deleterious to fish and wildlife. There are also criminal statutes making it unlawful to pollute waters of the State. The State Department of Health is the water pollution control agency designated to represent the State under the Federal Water Pollution Control Act.

Kansas

A high degree of control over water pollution from municipal sources has been established in the Kansas part of the basin. It has been the policy of the State Board of Health since 1940 to approve new sewerage facilities only when adequate treatment is also provided. Many of the community sewer systems in the basin have been constructed under that policy and waste treatment facilities are, in general, adequate in capacity and relatively new. Nine of the 14 community waste treatment plants have been constructed or extensively remodeled in the past five years. Eleven Kansas communities, representing a total population served of 19,250, provide secondary waste treatment facilities of adequate capacity. Three communities, representing a population of 1,750, have treatment plants which are unsatisfactory with respect to degree of treatment or capacity. Additional data concerning municipal treatment facilities are shown in Tables C, E, G, H and Table 1a of the Appendix.

Industrial waste is not, at present, a serious problem in the Kansas part of the basin. The principal waste discharge of the major industrial establishments is clean cooling water and extensive treatment facilities are not required. The numerous gas wells and development of oil fields in the Hugoton Area represent a potential hazard to the quality of basin ground and surface water resources and prevention of such pollution is very important.

The Kansas State Board of Health considers present legislation to be adequate, in general, for control of existing and potential pollution problems of the Kansas Basin.

The State Board of Health is the principal water pollution control agency in Kansas. However, two other agencies have limited pollution control powers. Rules and regulations of the Board which may affect fish and wildlife are subject to approval of the State Forestry, Fish and Game Commission. Responsibility for control of brine pollution from oil and gas fields is divided between the Board of Health and the Corporation Commission. Plans and specifications for brine disposal facilities must be approved by both agencies. The principal interest of the Commission is conservation of gas and petroleum resources; that of the Board of Health is protection of water resources from preventable pollution. If the Board finds a brine disposal well to be the most feasible method of pollution abatement, it so certifies to the Commission. The Corporation Commission issues necessary orders and any required hearing is held before the Commission. The Corporation Commission is also responsible for investigations necessary to determine whether abandoned oil or gas wells are polluting or likely to pollute fresh water aquifers or surface supplies and for assuring that such wells are adequately plugged to prevent further pollution or danger of pollution. The Board of Health may prohibit use of surface ponds for brine disposal where water resources may be damaged by such ponds.

Water pollution control has been an important activity of the Kansas State Board of Health since passage of the Water and Sewage Law of 1907. The Board is specifically authorized to regulate both municipal and industrial sources of pollution and to control pollution detrimental to public health or to animal and aquatic life. The Board also has broad powers and duties related to water supply which may involve pollution control or abatement measures

The Division of Sanitation is the agent of the Kansas State Board of Health, in pollution control matters, through its Water Pollution Control and Oil Field Sections. The Water Pollution Section is concerned with all types of pollution including industrial process wastes and pollution abatement measures. The Oil Field Section is responsible for investigations of the causes and effects of pollution by wastes resulting from production of oil and gas. The Oil Field Section also cooperates with the industry and other agencies in development of effective and economical disposal and control facilities for such wastes.

General pollution control measures in effect which are applicable to the Cimarron River Basin include:

1. Promotion programs designed to inform and assist local groups in development and maintenance of waste treatment facilities.

2. Review of plans and specifications for waste disposal facilities.

3. Inspection and evaluation of operating efficiency of existing waste treatment and disposal facilities.

4. General stream pollution surveys and investigation of specific pollution complaints.

5. Supervision of educational programs for plant operators and consultation services, in connection with pollution problems, for communities, institutions, industries, and individuals.

Oklahoma

Water pollution originating in the lower reach of the Cimarron River in Oklahoma represents one of the most difficult pollution control problems in the Arkansas River Basin. Pollution includes municipal sewage, silt, and salinity contributed by natural and industrial sources. Abatement of natural and industrial salinity, in particular, is subject to serious technical and practical difficulties.

Considerable progress has been made toward control of municipal and industrial pollution and soil conservation practices have reduced land erosion. Little or no control has been established over chemical pollution from natural sources.

Twenty-five community sewer systems in the Cimarron River Basin serve a total of about 102,400 persons. Sixteen communities, representing a sewered population of about 83,500, provide secondary treatment facilities; seven communities provide primary treatment only for wastes from an estimated population of 9,700; two cities, providing sewerage facilities for about 9,200 persons, have no waste treatment facilities. Additional data concerning existing municipal waste treatment facilities are included in Tables C, E, G, H and Table 1a of the Appendix.

Oil production and processing is the principal industry in the basin. There are ten major oil production areas in the basin, only three of which have brine disposal facilities considered adequate by the State Planning and Resources Board. The other seven areas provide satisfactory facilities for disposal of from 20 to 95 percent of brine produced. There are four oil refineries, none of which have adequate waste disposal facilities. Additional data concerning existing industrial waste facilities are shown in Tables B, D, and F.

Responsibility and authority for water pollution control in Oklahoma is divided among four agencies, the Oklahoma State Department of Health, the State Planning and Resources Board, the Department of Game and Fish and the Corporation Commission. In general, responsibility for protection of the surface and ground water resources of the State and control of pollution due to industrial wastes is shared by the Planning and Resources Board and the Department of Health. Control of pollution due to domestic sewage is the responsibility of the Department of Health. The Department of Game and Fish is authorized to take legal action on waste discharges which are detrimental to fish and wildlife. The major concern of the Corporation Commission

is conservation of oil and gas, but it has water pollution control powers because of its authority to regulate the secondary recovery of oil and control the plugging of abandoned oil wells for the protection of fresh water resources. Coordination of the pollution control activities of the four agencies is maintained by an informal inter-agency committee on which all are represented.

The Pollution Department of the Division of Water Resources is the agency of the Oklahoma Planning and Resources Board directly responsible for oil field waste pollution control. It was established in 1937 and, in general, oil fields developed since that date have provided adequate waste disposal facilities or are planning to do so. Brine pollution problems originate almost exclusively in fields developed prior to that time. Personnel of the Pollution Department is available to industry for consultation in development of satisfactory facilities for brine disposal.

The Division of Water Resources is sponsoring, in cooperation with the U. S. Geological Survey, water quality studies at control points over the State which are very useful in determining degree of chemical pollution.

Plans and specifications for municipal waste treatment facilities are reviewed by the Bureau of Sanitary Engineering of the State Health Department and a program of inspection and evaluation of operating efficiency of existing municipal facilities is carried on. Mobile laboratory services are available through the Bureau of Sanitary Engineering for general stream pollution surveys, investigation of pollution complaints and study of plant capacity requirements for treatment of municipal and industrial wastes. Personnel of the Bureau of Sanitary Engineering is available for consultation concerning waste treatment problems or facilities, to municipalities, industries, institutions and individuals.

An active training program for treatment plant operators is carried on by the Oklahoma Water, Sewage and Industrial Waste Conference. The State Department of Health and Oklahoma A & M College support the program by providing instructors for regular district meetings, and an annual short course for plant operators is held at A & M College. All of the State agencies interested in pollution control actively sponsored an industrial wastes conference in December 1952. However, the effectiveness of such programs is severely limited by turnover in operating personnel and inability of many operators to attend courses of instruction. Operators of small community plants and industrial waste treatment and disposal plants are least likely to receive full benefit from existing training programs and, in general, are the operator classifications most in need of such training.

In addition to pollution control activities in cooperation with the Planning and Resources Board and the State Department of Health, the State Department of Game and Fish has carried on an active independent stream pollution abatement program in the past few years. That program has been confined to instances in which damage to fish and wildlife has occurred as a result of waste discharges or other pollution conditions. Activity of the Department of Game and Fish in the Cimarron River Basin has not been very extensive.

POLLUTION PREVENTION MEASURES REQUIRED

New Mexico and Colorado

No specific pollution control measures are required at the present time in the New Mexico or Colorado portions of the basin. There are no industrial sources of pollution in either area and only two municipal sources of pollution, both of which are in Colorado. The general pollution control programs of the States appear to be adequate for control of existing pollution problems.

While water pollution is not a serious problem at present in the Colorado and New Mexico sections of the Cimarron River Basin, water supply deficiencies exist in both areas. Possible additional sources of water supply are very limited in number. Protection and conservation of existing supplies are very important.

Kansas

The southwestern corner of Kansas is one of the few areas in the Cimarron River Basin in which water supply beyond immediate needs is available. The source of this supply is a huge underground reservoir underlying the "High Plains" region. Serious pollution of that reservoir would irreparably damage the water resources of the Kansas Basin.

The development of the Hugoton gas field represents a possible threat to ground water resources of the area. The most important requirement for protection of basin water resources is adequate legislation and clear definition of responsibility for plugging of abandoned wells and other perforations passing through ground water supply strata. In addition to legislation, a means of financing the plugging of abandoned wells for which individual responsibility cannot be fixed and for adequate supervision of plugging practice is necessary.

Legislation for control of municipal and industrial pollution is considered generally adequate.

Oklahoma

From a water use point of view, chemical pollution of the Cimarron River from natural and industrial sources in Oklahoma is the most significant pollution problem in the basin.

The high degree of mineralization of the Cimarron River is indicated by the analyses summarized in Table 3a of the Appendix. The weighted averages and the extreme variations in maximum and minimum values show that the water is rarely suitable for any higher water use. The enormous potential polluting capacity of oil field brine is indicated by the analyses of typical brines shown in Table 4a of the Appendix. The analyses represent a salt content, calculated as NaCl, of nearly 70 pounds of salt per 42 gallon barrel of brine. 1948 oil production in the basin was over 15 million barrels, or an average of about 41,000 barrels a day. At least in older fields, brine production may exceed oil production by more than 5 to 1. One barrel of

brine per barrel of oil production would represent about 1,440 tons of salt (as naCl) per day. Since seven major oil fields in the basin (See Table L), according to the Pollution Department of the Division of Water Resources-Oklahoma Planning and Resources Board, do not have adequate brine disposal facilities extensive brine pollution is obviously possible.

In addition to oil field brines, heavy chemical pollution is derived from salt springs and salt and gypsum deposits on the main stem and tributaries of the river between the Kansas State line and Waynoka, Oklahoma. The limited amount of data available indicate that these natural sources may represent a greater average mineral contribution than the oil fields.

Analyses at the Mannford, Oklahoma, gaging station represent both natural and brine pollution. The magnitude and control difficulties involved in the chemical pollution problem of the Cimarron River Basin indicate that extensive study of possible abatement measures is justified. At least the following measures are necessary:

1. Establishment of a continuous flow and water quality measurement program at Waynoka, Oklahoma, for a sufficient length of time to accurately define the magnitude of natural pollution.

2. A thorough study of the specific sources of natural pollution, such as saline springs, and possible abatement procedures.

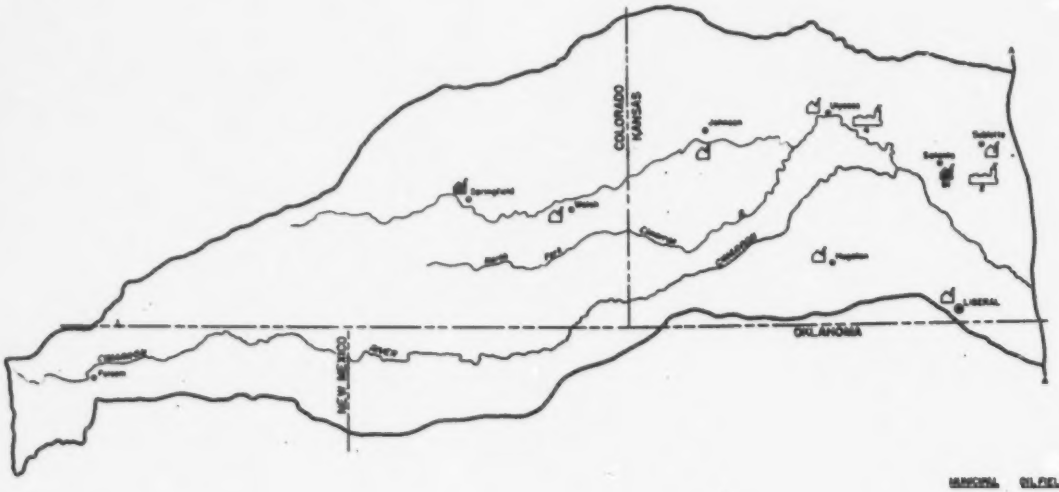
3. Control of brine production by oil fields and other industrial sources which do not provide adequate disposal facilities.

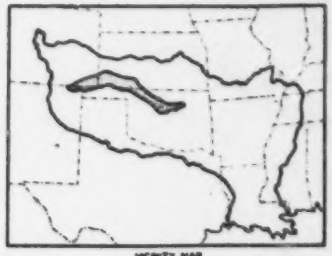
4. Continued cooperation between State authorities and industry in development of adequate disposal facilities.

5. Close supervision of operation of existing brine disposal facilities.

Although most of the municipalities in the basin have waste treatment facilities, many are deficient or inadequate. Only five, of the 23 existing municipal plants in the Oklahoma Basin, are considered completely satisfactory. They serve a population of about 5,500. Table H shows that two communities, combined population 9,250, need new plants; 17 plants serving a population of 55,700 are inadequate in capacity; replacement of one plant serving 32,000 persons is required. The operation of 13 plants is considered unsatisfactory.

Map Number 3 shows municipal and industrial waste treatment needs. Table D shows that 12 industrial plants, of a total of 19 in the Oklahoma Basin discharging pollution wastes from separate outlets, provide waste treatment facilities. However, Tables F and I indicate that 9 are inadequate in capacity; three industries need new plants; and treatment requirements of 4 industries have not been determined. Three industries have adequate treatment facilities.





MUNICIPAL	OILFIELD AREAS	OTHER INDUSTRY	
			NO NEEDS
			NEEDS UNDETERMINED
			PROJECT NEEDED

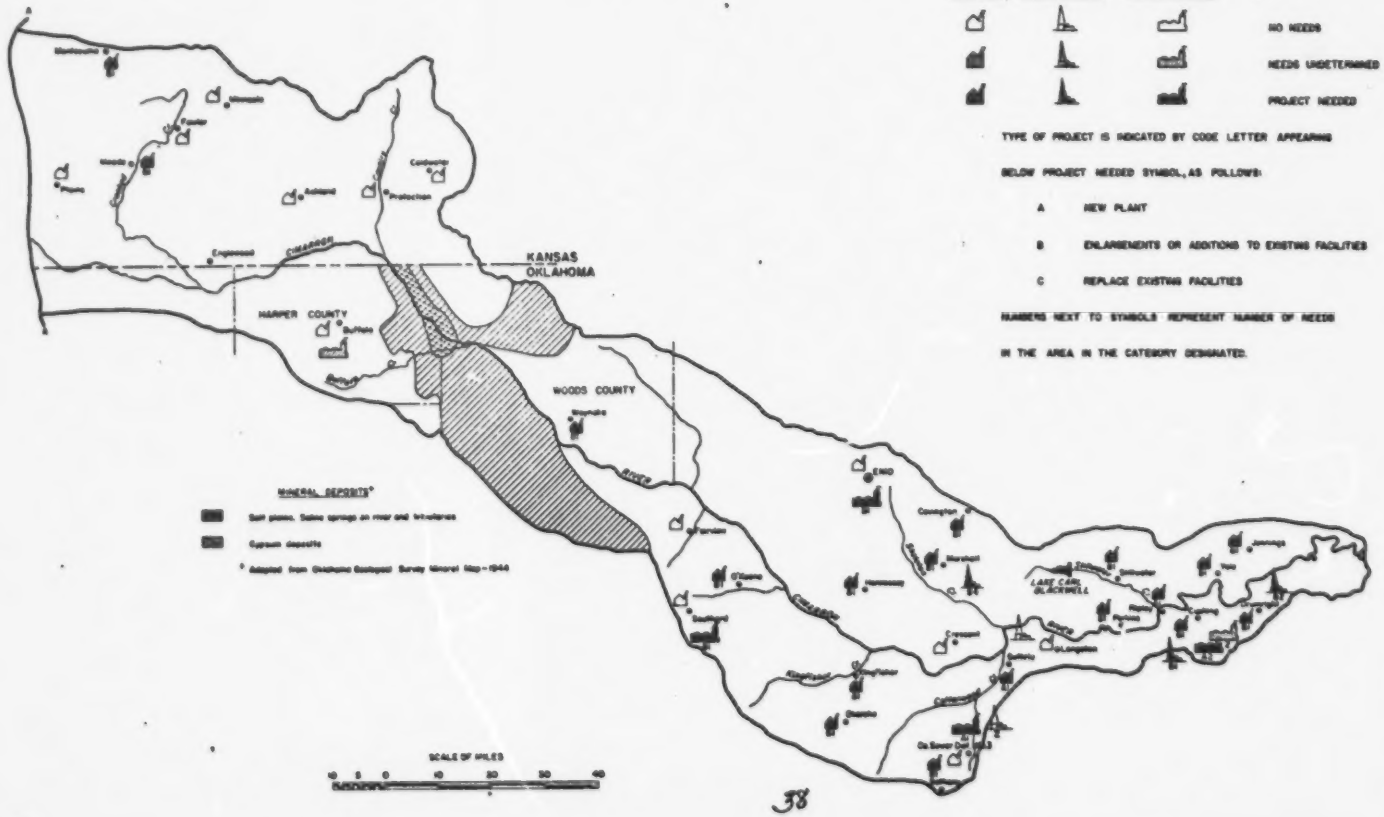
TYPE OF PROJECT IS INDICATED BY CODE LETTER APPEARING BELOW PROJECT NEEDED SYMBOL, AS FOLLOWS:

A NEW PLANT

B ENLARGEMENTS OR ADDITIONS TO EXISTING FACILITIES

C REPLACE EXISTING FACILITIES

NUMBERS NEXT TO SYMBOLS REPRESENT NUMBER OF NEEDS IN THE AREA IN THE CATEGORY DESIGNATED.



CIMARRON RIVER BASIN

MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Pollution Control
Map No. 3

Table J shows the current status of action by municipalities on pollution abatement needs. Five municipalities are actively planning improvements, fifteen needed projects are inactive. Status of action by industry is indicated in Table K. One project is planned, 11 are inactive and the status of four is undetermined.

Additional data concerning municipal and industrial pollution abatement needs are shown in Table L. It is estimated that the cost of required municipal improvements, to correct existing deficiencies, would be about $2,000,000. Nearly half of the estimate is for replacement of the Enid, Oklahoma, plant which is now under construction. The cost of correction of chemical pollution depends on so many variable factors that no reliable estimate can be made.

Pollution of the Cimarron River is so varied and extensive that correction will require the cooperation of all State, local and Federal agencies concerned with water or soil conservation and pollution control as well as industry and municipalities. The magnitude of the pollution problem and practical difficulties involved for abatement indicate that a long-range approach to control will be necessary.

TABLE C

EXISTING TREATMENT FACILITIES

MUNICIPAL

Degree of Treatment Provided	Number of Municipalities Served		Number of Treatment Plants	Population Served
Primary	Colorado	2	2	2,400
	Kansas	2	2	450
	Oklahoma	7	8	9,700
Secondary	Colorado	0	0	0
	Kansas	12	12	20,550
	Oklahoma	16	15	83,450
No Treatment	Colorado	0	--	0
	Kansas	0	--	0
	Oklahoma	2	--	9,250

Note: There are no sources of municipal pollution in the New Mexico portion of the basin.

TABLE D

EXISTING TREATMENT FACILITIES

INDUSTRIAL

Type Industry*	Number of Plants		Number of Industrial Plants Having:		
			Treatment Facilities	No Treatment Facilities	Undetermined Facilities
Food Products	Oklahoma	1	0	0	1
Chemical Products	Oklahoma	1	1	0	0
Petroleum Products	Oklahoma	6	1	5	0
Oil Production	Oklahoma	10	10	0	0

* Industries having separate outlets discharging directly to watercourses

Note: There are no significant waste producing industries in the New Mexico and Colorado portions of the basin.

TABLE E

ADEQUACY OF EXISTING TREATMENT FACILITIES
MUNICIPAL

Number of Municipal Treatment Facilities	Adequacy with Relation to:					
	Capacity			Operation		
	Satisf.	Unsatisf.	Undetermined	Satisf.	Unsatisf.	Undetermined
Colorado 2	1	1	0	--	--	2
Kansas 14	11	3	0	9	4	1
Oklahoma 23	6	17	0	10	13	0

Note: There are no sources of municipal pollution in the New Mexico portion of the basin.

TABLE F

ADEQUACY OF EXISTING TREATMENT FACILITIES
INDUSTRIAL

Number of Industrial Treatment Facilities	Adequacy with Relation to:					
	Capacity			Operation		
	Satis.	Unsatisf.	Undetermined	Satisf.	Unsatisf.	Undetermined
Oklahoma 12	3	9	0	10	1	1

TABLE G

PROGRESS IN CONSTRUCTION OF POLLUTION ABATEMENT FACILITIES

Year	Municipal		Industrial	
	Sewage Treatment Plants Completed	Design Population	Waste Treatment Plants Completed	Amount of Waste Treated (In terms of Equiv. No. People)
1948	Colorado 1 Kansas 3	750 4,300	No Data Available	
1949	Kansas 1	4,000	--	--
1950	Kansas 1 Oklahoma 4	4,000 10,400	--	--
1951	Kansas 2	1,600	--	--
1952	Kansas 1	1,000	--	--

TABLE H

WASTE TREATMENT NEEDS - MUNICIPAL

Needs	Number	Population Served by Facilities
New Plant	Oklahoma 2	9,250
Enlargement or Additions to Existing Plant	Kansas 3 Oklahoma 17	1,750 55,700
Replace Existing Plant	Colorado 1 Oklahoma 1	2,040 32,000
No Project Required	Colorado 1 Kansas 11 Oklahoma 5	360 19,250 5,500

Note: There are no sources of municipal pollution in the New Mexico portion of the basin.

TABLE I

INDUSTRIAL WASTE POLLUTION ABATEMENT NEEDS

Needs	Number
New Treatment Plant or other Pollution Control Measures	Oklahoma 3
Enlargement or Additions to Existing Plant	Oklahoma 9
Replace Existing Plant	
Connection to Municipal Sewer System	
No Project Required	Oklahoma 3
Undetermined	Oklahoma 3

Note: There are no significant waste producing industries in the New Mexico and Colorado portions of the basin.

TABLE J

CURRENT STATUS OF MUNICIPAL ACTION ON

POLLUTION ABATEMENT NEEDS

Status of Action	Number of Municipalities	
Inactive	Kansas Oklahoma	2 15
Active Planning	Kansas Oklahoma Colorado	1 2 1
Final Plans Approved	---	
Under Construction	Oklahoma	1

Note: There are no sources of municipal pollution in the New Mexico portion of the basin.

TABLE K

CURRENT STATUS OF INDUSTRIAL ACTION ON

POLLUTION ABATEMENT NEEDS

Status of Action	Number of Industries	
Inactive	Oklahoma	11
Active Planning	Oklahoma	1
Final Plans Approved	---	
Under Construction	---	
Undetermined	Oklahoma	4

Note: There are no significant waste producing industries in the New Mexico and Colorado portions of the basin. Kansas industries, in general, discharge wastes into municipal sewer systems.

TABLE L

MUNICIPALITIES AND INDUSTRIES NEEDING
IMPROVEMENTS FOR ABATEMENT OF POLLUTION

Name and Location	Population Served	Improvements Needed (*)	Remarks
Colorado			
Municipalities			
Springfield	2,025	R	Active Planning
Kansas			
Municipalities			
Meade	1,300	E-A	Active Planning
Montezuma	200	E-A	Inactive
Santanta	250	E-A	Inactive

The major industrial establishments in the Kansas Basin are four gasoline plants and four carbon black plants processing natural gas from the Hugoton Field. It is understood that, under normal operating conditions, they do not constitute significant sources of industrial pollution.

Oklahoma			
Municipalities			
Bethany	6,000	E-A	Active Planning
Covington	750	E-A	Inactive
Cushing	8,000	E-A	Inactive
Plant No. 1			
Plant No. 2			
Drumright	4,500	E-A	Inactive
Enid	32,000	R	Under Construction
Guthrie	9,000	NP	Inactive
Hennessey	1,200	E-A	Inactive
Jennings	225	E-A	Inactive
Kingfisher	2,800	E-A	Inactive
New Marshal	300	E-A	Inactive
Okarche	450	E-A	Inactive
Okeene	1,050	E-A	Inactive
Perkins	700	E-A	Inactive
Ripley	250	NP	Inactive
Stillwater	22,000	E-A	Inactive
Veterans Village	Served by Stillwater Plant		

TABLE L cont'd

Name and Location	Population Served	Improvements Needed (*)	Remarks
Waynoka	1,500	E-A	Inactive
Yale	1,200	E-A	Active Planning
Oklahoma			
Industries			
Buffalo			
1 Meat Processing Plant		Undetermined	
Cushing			
2 oil refineries		NP	Inactive
2 oil reclamation plants		Undetermined	
Edmond			
1 oil refinery		NP	Inactive
Enid			
1 oil refinery		E-A	Inactive
Southard			
1 chemical plant		E-A	Under Construction
Creek County			
Drumright Oil Field Area		E-A	Disposal Facilities 20% adequate
Mannford Oil Field Area		E-A	Disposal Facilities 30% Adequate
Logan County			Disposal Facilities
Coyle Oil Field Area		E-A	45% adequate
Crescent Oil Field Area		E-A	Disposal Facilities 95% adequate
Marshal Oil Field Area		E-A	Disposal Facilities 85% adequate
Roxana Oil Field Area		E-A	Disposal Facilities 60% adequate
Payne County			
Cushing Oil Field Area		E-A	Disposal Facilities 70% adequate

* NP -- New Plant
E-A -- Enlargement or addition to existing plant
R -- Replacement of existing plant

TABLE 1a

BASIC DATA ON SOURCES OF MUNICIPAL* POLLUTION
CIMARRON RIVER BASIN
December 1952

Watercourse — Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes (Est.)	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Water-course (Est)	Treatment Needs*	Current Status Municipal Action
					Cap'y	Opr.			
CIMARRON RIVER (Headwaters near Capulin Mountain National Monument, New Mexico									
New Mexico	635.0								
New Mexico-Colorado Line									
Colorado									
North Fork									
Bear Creek									
Springfield		2,025	2,050	Primary	Unsat.	Und.	1,350	R	Active Planning
Walsh		360	350	Primary	Sat.	Sat.	0	None	Inactive
Colorado-Kansas Line									
Kansas									
North Fork									
Johnson		900(E)	900	Secondary	Sat.	Und.	225(E)	None	
Ulysses		2,000	2,000	Secondary	Sat.	Sat.	500	None	
Tributary Cimarron River									
Hugoton		2,000	2,000	Secondary	Sat.	Sat.	0	None	
Tributary Cimarron River									
Sublette		700	700	Secondary	Sat.	Unsat.	0	None	
Satanta	431.2	250	250	Primary	Unsat.	Sat.	175	E-A	Inactive
Tributary Cimarron River									

TABLE 1a cont'd

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers (Est.)	P.E. (B.O.D.) Untreated Wastes	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourse (Est.)	Treatment Needs *	Current Status Municipal Action
					Cap'y	Opr.			
Plains		Und.	700	Secondary	Sat.	Sat.	Und.	None	
Tributary									
Cimarron River									
Liberal	400.0	8,500	8,500	Secondary	Sat.	Sat.	0	None	
Kansas-Oklahoma Line 1/									
Crooked Creek	349.4								
Montezuma, Kansas		200	200	Primary	Unsat.	Unsat.	50	E-A	Inactive
Fowler, Kansas		700 (E)	700 (E)	Secondary	Sat.	Sat.	175 (E)	None	
Meade, Kansas		1,300	1,300	Secondary	Unsat.	Unsat.	500	E-A	Active Planning
Oklahoma-Kansas Line 1/									
Sand Creek									
Bear Creek									
Ashland, Kansas		1,450	1,450	Secondary	Sat.	Unsat.	350	None	
Buff Creek									
Minneola, Kansas		500	500	Secondary	Sat.	Sat.	125	None	
Cavalry Creek									
Coldwater		1,150	1,150	Secondary	Sat.	Sat.	300	None	
Protection		700	700	Secondary	Sat.	Unsat.	175	None	
Kansas-Oklahoma Line									
Oklahoma									
Buffalo Creek	280.0								
McMinn Creek									
Buffalo, Okla.		1,400	1,400	Secondary	Sat.	Unsat.	350	None	
Sand Creek									
Edith (Salt Springs)		None (Natural pollution from Salt Springs)							

TABLE 1a cont'd

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes (Est.)	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourse(Est)	Treatment Needs *	Current Status Municipal Action
					Cap'y	Opr.			
Dog Creek									
Waynoka	247.0	1,500	1,500	Primary	Unsat.	Unsat.	1,200	E-A	Inactive
Eagle Chief Creek									
Sand Creek									
Fairview		2,100	2,100	Secondary	Sat.	Unsat.	500	None	
Spring Creek									
Southard		80	80	Secondary	Sat.	Sat.	20	None	
Okeene		1,050	1,050	Secondary	Unsat.	Sat.	250	E-A	Inactive
Turkey Creek	161.8								
Hennessey		1,200	1,200	Primary	Unsat.	Unsat.	950	E-A	Inactive
Kingfisher Creek	158.2								
Uncle John Creek									
Okarche		450	450	Secondary	Unsat.	Unsat.	150	E-A	Inactive
Kingfisher		2,800	2,800	Secondary	Unsat.	Unsat.	700	E-A	Inactive
Cottonwood Creek	123.0								
Oklahoma Co. Sewer District #3		7,000	7,000	Secondary	Sat.	Sat.	350	None	
Bethany		6,000	6,000	Secondary	Sat.	Sat.	1,000	E-A	Active Planning
Guthrie	121.8	9,000	12,000	None	--	--	12,000	NP	Active Planning
Skeleton Creek	115.3								
Enid		32,000	32,000	Secondary	Unsat.	Sat.	8,000	R	Under Const.
Otter Creek									
Covington		760	760	Primary	Unsat.	Unsat.	600	E-A	Inactive
(New) Marshall		300	300	Primary	Unsat.	Sat.	200	E-A	Inactive
Wolf Creek									
Crescent		1,100	1,100	Secondary	Sat.	Sat.	200	None	
Tributary Cimarron River									
Langston		800	800	Secondary	Sat.	Unsat.	200	None	

TABLE 1a cont'd

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes (Est.)	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourses (Est)	Treatment Needs *	Current Status Municipal Action
					Cap'y	Opr.			
Perkins	87.3	700	700	Secondary	Unsat.	Sat.	200	E-A	Inactive
Stillwater Creek	75.9								
(Lake Carl Blackwell)									
Stillwater 2/		22,000	22,000	Secondary	Unsat.	Sat.	1,500	E-A	Inactive
Perkins	87.3	700	700	Secondary	Unsat.	Sat.	200	E-A	Inactive
Ripley		250	250	None	--	--	250	NP	Inactive
Mud Creek									
Yale		1,200	1,200	Primary	Unsat.	Unsat.	950	E-A	Active Planning
Euchee Creek									
Cushing		8,000	8,000	Secondary	Unsat.	Sat.	2,000	E-A	Inactive
Tributary Cimarron River									
Drumright		4,500	4,500	Primary	Unsat.	Unsat.	3,600	E-A	Inactive
House Creek									
Jennings		225	225	Primary	Unsat.	Unsat.	150	E-A	Inactive
Mouth Cimarron River	0.0								

1/ The Cimarron River dips into Oklahoma and returns to Kansas at these points. There are no major tributaries or towns in the Oklahoma section

2/ Including Veterans Village

* NP - New plant
E-A - Enlargement or Addition to Existing Plant
R - Replacement

SIGNIFICANT CHEMICAL CHARACTERISTICS OF BASIN WATER SUPPLIES
(CIMARRON RIVER BASIN)

Community	Iron ppm (Fe)	Calcium ppm (Ca)	Magnesium ppm (Mg)	Sodium ppm (Na)	Bicarbonate ppm (HCO_3)	Sulfate ppm (SO_4)	Chloride ppm (Cl)	Nitrate ppm (NO_3)	Total Hardness (ppm $CaCO_3$)	Total Dissolved Solids (ppm)
COLORADO (Ground waters) (No community surface water supplies in basin)										
#Campo	0.1		-	-	180	33	9	pH 6.6	182	Color 5
#Pritchett	0.1		-	-	164	72	9	pH 6.4	192	Color 5
#Springfield	Trace		-	-	152	20	105	-	314	-
#Two Buttes	0.0		-	-	156	116	0	pH 7.6	224	Color 0
Walsh	-		-	-	-	-	-	-	-	-
KANSAS* (Ground waters) (No community surface water supplies in basin)										
#Ashland	0.07	164	59	60	259	482	44	7.1	652	1,026
#Coldwater	0.00	48	3.6	8.3	146	2.1	7.0	26.0	135	201
#Copeland	0.00	50	8.6	12.0	182	7.8	13.0	13.0	160	228
#Englewood	0.19	104	42	50	377	118	71	8.4	432	635
#Fowler	0.28	53	12	21	212	33	10	3.5	182	265
#Hugoton	0.04	74	37	47	240	195	18	14.0	336	586
#Johnson City	0.05	49	18	40	193	93	13	8.0	196	335
#Kismet	0.06	68	21	43	240	111	18	13.0	256	435
#Liberal	0.11	55	22	28	218	72	15	16.0	228	348
#Manter	0.05	62	17	34	237	75	14	5.3	224	335
#Meade	0.05	54	15	36	192	37	49	8.0	196	345
#Minneola	0.02	60	12	26	253	14	13	15.0	199	292
#Montezuma	0.08	54	10	22	193	29	14	16.0	176	260
#Moscow	0.03	46	29	49	228	114	16	11.0	234	388
#Plains	0.00	50	15	28	195	59	11	9.7	186	292
#Protection	0.11	84	23	39	281	107	31	1.1	304	460
#Rolla	0.03	69	28	51	224	168	21	12.0	287	499

TABLE 2a cont'd

Community	Iron ppm (Fe)	Calcium ppm (Ca)	Magnesium ppm (Mg)	Sodium ppm (Na)	Bicarbonate ppm (HCO_3)	Sulfate ppm (SO_4)	Chloride ppm (Cl)	Nitrate ppm (NO_3)	Total Hardness (ppm $CaCO_3$)	Total Dissolved Solids (ppm)
KANSAS cont'd										
#Satanta	0.48	68	26	59	235	167	18	14.0	276	504
#Sublette	0.03	45	20	60	16	135	97	3.2	194	419
#Ulysses	0.00	65	32	51	209	186	16	15.0	294	510
Maximum	0.48	164	59	60	377	482	97	26.0	652	1,026
Minimum	0.00	45	3.6	8.3	16	2.1	7	1.1	135	201
NEW MEXICO	(No community water supplies in basin)									
OKLAHOMA (Ground Waters)**										
Aline	-	-	-	-	-	-	-	-	-	-
Avard	-	-	-	-	-	-	-	-	-	-
#Buffalo	0.00	78	20	53	309	72	43	5.3	276	448
Carmen	-	83	23	86	388	91	61	0.0	300	-
#Covington	0.00	47	25	169	368	51	146	8.5	220	659
#Coyle	-	143	48	133	395	120	275	8.0	555	922
#Crescent	0.00	116	27	76	372	54	112	36.0	400	642
Drumright	-	52	19	32	244	63	8.2	0.9	208	300
#Edmond	0.01	20	7.9	243	409	68	150	3.5	82	712
#Enid	0.02	51	11	58	266	21	39	9.1	172	346
Fairview	0.10	64	27	30	261	30	17	32.0	262	-
#Forgan	-	-	-	-	308	36	22	17.0	260	-
#Freedom	0.00	300	56	85	259	726	113	36.0	979	1,470
#Gate	0.10	81	8	9	256	10	14	-	234	-
Goltry	-	-	-	-	-	-	-	-	-	-
Hallett	-	-	-	-	-	-	-	-	-	-
Helena	-	82	15	124	439	47	83	12.0	267	-
#Hennessey	0.00	114	34	93	266	25	250	26.0	424	825
Hitchcock	-	-	-	-	--	-	-	-	-	-
#Jennings	0.0	8	9	150	272	49	81	1.0	58	-
#Kingfisher	0.00	73	22	96	359	87	66	0.2	272	530

Community	Iron ppm (Fe)	Calcium ppm (Ca)	Magnesium ppm (Mg)	Sodium ppm (Na)	Bicarbonate ppm (HCO_3)	Sulfate ppm (SO_4)	Chloride ppm (Cl)	Nitrate ppm (NO_3)	Total Hardness (ppm $CaCO_3$)	Total Dissolved Solids (ppm)
OKLAHOMA cont'd										
#Langston University	0.00	148	44	179	350	141	322	38.0	550	1,070
Longdale	-	-	-	-	-	-	-	-	-	-
Mannford	0.04	40	19	24	169	25	20	38.0	178	282
Marshall (New)	0.00	88	25	87	331	105	85	0.9	322	570
Mulhall	0.00	188	58	72	476	145	165	75.0	708	966
Oilton	0.00	86	25	89	269	91	135	0.0	318	653
Okarche	-	-	-	-	-	-	-	-	-	-
#Okeene	0.00	68	17	73	327	59	46	0.5	240	449
Perkins	-	55	26	29	120	27	46	89.0	244	-
Quinlan	-	-	-	-	-	-	-	-	-	-
Ripley	0.0	158	57	37	431	141	58	200.0	628	-
Southard	-	76	19	31	258	76	32	-	269	-
#Wankomis	0.00	298	66	194	259	1,030	111	5.0	1,020	1,870
#Waynoka	0.00	68	11	28	224	31	16	44.0	215	333
Yale	Tr	19	6	6	81	5	10	-	73	-
Maximum	0.10	300	66	243	476	1,030	322	200.0	1,020	1,870
Minimum	0.00	8	6	6	81	5	8.2	0.0	73	300
OKLAHOMA (Surface Waters)**										
#Cushing	0.03	30	12	15	134	11	24	1.4	124	175
Guthrie	0.00	45	21	11	232	18	15	0.1	199	231
Stillwater	0.36	32	13	17	159	15	20	0.8	133	199
Maximum	0.36	45	21	17	232	18	24	1.4	199	231
Minimum	0.00	30	12	11	134	11	15	0.1	124	175

#Waters contain fluoride in range from 0.1 to 1.5 ppm

Data abstracted from:

*"Chemical Analyses, Kansas Municipal Water Supplies" (1950), Division of Sanitation, Kansas State Board of Health.

**"Public Water Supplies in Oklahoma"(1951) USGS in cooperation with Oklahoma Planning and Resources Board.

"The Chemical Analyses of the Waters of Oklahoma," (1942) Pub. No. 52, Engineering Experiment Station, Oklahoma A & M College.

TABLE 3a

CHEMICAL QUALITY OF WATER*

CIMARRON RIVER AT MANNFORD, OKLAHOMA

CONSTITUENT	FOR WATER YEAR 1949-50 (Full Year) MAXIMUM (ppm)	MINIMUM (ppm)	WEIGHTED AVERAGE (ppm)
Calcium (Ca)	460	46	126
Magnesium (Mg)	118	11	30
Sodium & Potassium (Na&K)	3,450	196	750
Potassium (K)	115	23	---
Bicarbonate (HCO_3)	269	92	157
Sulphate (SO_4)	491	36	196
Chloride (Cl)	6,050	335	1,230
Fluoride (F)	0.3	0.0	---
Nitrate (NO_3)	14	0.7	5.1
Dissolved Solids	10,500	739	2,420
Hardness ($CaCO_3$)			
Total	1,710	222	438
Non-carbonate	1,580	73	310
Percent sodium	82	68	79
Spec. Cond. (mmhos @25°C)	16,800	1,160	4,160
Mean Discharge (cfs)	25,000	137	1,707

*"Chemical Character of Surface Waters in Oklahoma," 1949-50, Oklahoma Planning and Resources Board.

TABLE 4a

CHEMICAL ANALYSES OF REPRESENTATIVE BRINES*

Source	Calcium (ppm Ca)	Magnesium (ppm Mg)	Sodium (ppm Na)	Bicarbonate (ppm HCO_3)	Sulfate (ppm SO_4)	Chloride (ppm Cl)
Bartlesville Sand	11,251	1,854	50,899	78	45	104,298
Cromwell Sand	7,844	1,612	40,930	73	113	81,567
Hunton Limestone	9,183	1,738	52,583	64	618	102,021
Layton Sand	9,764	2,391	51,569	40	176	103,678
Tonkawa Sand	14,371	2,506	70,789	8	149	141,725
Wilcox Sand	8,970	1,841	52,163	46	393	101,217
Texaco Well No. 1 Tulsa, Oklahoma	10,836	2,137	51,827	65	425	106,200
Average	10,317	2,011	52,966	54	274	105,815

*Analyses abstracted from:

"The Chemical Analyses of the Waters of Oklahoma," 1942, Publication Number 52, Engineering Experiment Station, Oklahoma A&M College.

TABLE 5a

RIVER WATER ANALYSES*

Stream, Location and Period of Record	Mean Discharge (cfs)	WEIGHTED AVERAGE VALUES								
		Calcium ppm (Ca)	Magnesium ppm (Mg)	Sodium & Potassium ppm (Na&K)	Bicarbonate ppm (HCO_3)	Sulfate ppm (SO_4)	Chloride ppm (Cl)	Total Hardness ppm ($CaCO_3$)	Total Dissolved Solids ppm	Percent Sodium
ARKANSAS RIVER										
Ralston, Oklahoma (Jan.1 to Oct.1, 1950)	6,819	66	16	160	149	108	240	230	702	60.0
CIMARRON RIVER										
Mannford, Oklahoma (Jan.1 to Oct.1, 1950)	2,090	113	27	670	141	175	1,100	392	2,180	63.0
ARKANSAS RIVER										
Sand Springs, Oklahoma (Jan. 1 to Oct. 1, 1950)	9,315	84	20	329	154	132	523	292	1,200	71.0
ARKANSAS RIVER **										
Little Rock, Ark. (Water Year 1946-47)	47,590	39	9	91	108	47	137	135	419	57.0
CIMARRON RIVER										
Mannford, Oklahoma (Water Year 1949-50)	1,707	126	30	750	157	196	1,230	438	2,420	70.0
CIMARRON RIVER**										
Ute Park, N.M. (Water Year 1946-47)	30	39	9	13	164	16	4	133	176	14.0
CIMARRON RIVER**										
Mocane, Oklahoma (Water Year 1946-47)	113	77	33	266	226	143	387	328	1,040	64.0

*Data abstracted from "Chemical Character of Surface Waters of Oklahoma", 1949-50, Division of Water Resources, Oklahoma Planning and Resources Board.

**Data abstracted from "Quality of Surface Waters of the United States, 1947," Geological Survey Water Supply Paper 1100.